THE ASTROPHYSICAL JOURNAL, Vol. 156, April 1969

PHOTOELECTRIC SCANNER OBSERVATIONS OF CH CYGNI FOR AUGUST 3, 1967

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Received August 28, 1968

ABSTRACT

Twelve scans of the CH Cygni spectrum (taken after the report of a variable violet continuum) from 3300 to 5000 Å have been calibrated in relative flux units by comparison with Oke's standards; for comparison, 45 Arietis, which has a similar spectrum to the preoutburst, M-type, CH Cygni spectrum, was also observed and calibrated. High-dispersion spectra taken on the same night are also shown, and graphs of the variations of the excess blue and ultraviolet continua and a table of integrated Hβ emission measures are presented. Most of the excess radiation can be explained in terms of Balmer continuum and line emission, but there is a weaker continuum at other wavelengths increasing in intensity toward short wavelengths which appears when the Balmer continuum brightens. These results are very similar to those reported for the short-lived flares associated with certain dMe stars and suggest that CH Cygni may be detectable at radio wavelengths during an outburst.

I. INTRODUCTION

Deutsch (1967) reported in June 1967 that the spectrum of the 7.5-mag M star CH Cygni (HD 182917) showed the presence of a blue and ultraviolet continuum and several strong P Cygni–type emission lines of H, He, [Fe II], and the H and K lines of Ca II. Soon after, Martel-Chossat (1967) reported that the star shows rapid light variations in the ultraviolet. Cester (1967*a*, *b*) also reported irregular variations in the blue. A similar outburst in 1963 was reported by Deutsch (1964), when the spectrum closely resembled that of the recurrent nova T Corona Borealis a few months before its nova outburst in 1945. Yamashita (1967) has classified the preoutburst spectrum of CH Cygni as M7⁻IIIab. The emission-line spectrum between 3140 and 3500 Å has been discussed by Swings and Swings (1967). They found lines of Fe II, Mn II, Cr II, Ti II, and perhaps Fe III. Faraggiana (1968) has described the spectrum in the normal photographic region between 3400 and 5050 Å and compared it with spectra of 30 Herculis (M6 III) and VV Cephei. Apart from the lines discussed by Swings, she has found sharp emission lines of [Fe II] and [S II]. There was evidence of continuous emission increasing from red to violet which filled in the absorption lines.

Wallerstein (1968) made observations on the *UBVr* system of Sandage and Smith (1963) of CH Cygni in August 1967. He confirmed the rapid ultraviolet fluctuations and found smaller fluctuations at other wavelengths. He concluded that not all the variation is caused by hydrogen emission.

II. OBSERVATIONS

We made scans on the nights of August 2, 3, and 4, U.T., 1967, using a photoelectric spectral scanner designed by R. Tull and mounted at the Cassegrain focus of the 48-inch telescope. Spectra of 15 Å mm^{-1} were also taken during this period with the Cassegrain spectrograph of the 72-inch telescope.

The fluctuations of the continuum brightness were similar in form on all three nights. Only the observations from August 3, 1967, are described here, as they are the most extensive. The spectrum was scanned from 3300 to 5000 Å with a resolution of 20 Å and at a rate of 500 Å min^{-1}. The detector was an EMI 9558 QA (S20 response) photomultiplier cooled to 0° C. A d.c. output was displayed in the normal way on a strip-chart recorder. The star HD 185780 was observed throughout the night both to act as a standard and to provide extinction corrections. The observations of HD 185780 were calibrated in abolute flux units by reference to Oke's standards (1964) which have been calibrated in terms of a known black-body source. The star 45 Arietis, which has an MK type of M6⁻IIIab according to Yamashita (1967), was observed at a later date as a comparison.

The spectra of both CH Cygni and 45 Arietis were corrected for extinction and calibrated in relative flux units at each of the wavelengths listed in Table 1. These wavelengths represent a uniform grid in the ultraviolet, and in the blue and green they avoid the stronger emission lines. The points at the wavelengths λλ4961, 4766, and 4596 correspond to wavelengths of minimum intensity near the absorption band heads of the TiO molecule in an M-type spectrum, and λλ4944, 4752, and 4570 correspond to wavelengths of maximum intensity. In order not to eliminate any possible additional blue-green continuum in the CH Cygni spectrum when comparing with that of 45 Arietis, the spectrum of 45 Arietis has been matched with each of those of CH Cygni according to the condition:

TABLE 1

WAVELENGTHS OF NORMAL POINTS MEASURED IN SPECTRAL SCANS OF CH CYGNI AND 45 ARIETIS

λ (Å)	λ (Å)	λ (Å)	λ (Å)
4977	4623	4077	3627
4961*	4596*	4027	3577
4944†	4570†	3977	3527
4877	4527	3927	3477
4827	4477	3877	3427
4766*	4417	3827	3377
4752†	4377	3777	3327
4727	4327	3727	..
4677	4277	3677	...

Mean difference in spectral intensity between wavelengths marked † and * in spectrum of 45 Arietis normalized to the difference in spectral intensity of CH Cygni at the same wavelengths.

$$[(F_{4944}+F_{4752}+F_{4570})-(F_{4961}+F_{4766}+F_{4596})]_{45\ \mathrm{Ari}}$$
$$=K[(F_{4944}+F_{4752}+F_{4570})-(F_{4961}+F_{4766}+F_{4596})]_{\mathrm{CH\ Cyg}}\,,$$

where $(F_\lambda)_{\mathrm{CH\ Cyg}}$ and $(F_\lambda)_{45\ \mathrm{Ari}}$ are the relative fluxes at the wavelength λ in the spectra of CH Cygni and 45 Arietis, respectively. A constant scale factor would have to be applied to convert these to absolute units.

The differences $K(F_\lambda)_{\mathrm{CH\ Cyg}} - (F_\lambda)_{45\ \mathrm{Ari}}$ are shown graphically for the twelve scans in Figure 1. The universal time appropriate to each scan is also given. In Table 2 integrated measures of the emissions at Hβ are given in Ångstroms and the same relative flux units as those in Figure 1. These measures were derived from planimeter measures on the tracings.

III. DISCUSSION

Figure 1 and Table 2 confirm the rapid fluctuations in the ultraviolet continuum and line emission already reported by other observers. There appear, for example, to have been a minimum of activity at the time of scan 3 and a maximum near the time of scan 9.

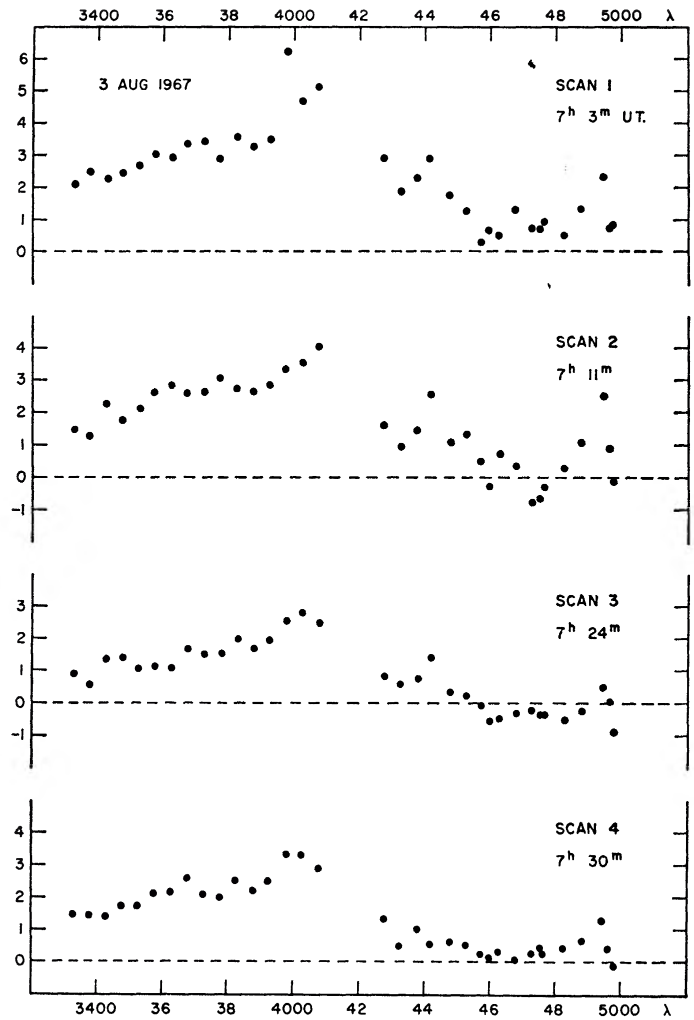

FIG. 1.—Excess continuum radiation in spectrum of CH Cygni relative to standard M6⁻IIIab spectrum of 45 Arietis, for twelve scans taken on the night of August 3, U T., 1967. Ordinate is in flux units with an arbitrary scale factor applied. Details of the calibration of individual scans in absolute flux units using Oke's (1964) standards and fitting and normalization of the CH Cygni spectra to those of 45 Arietis in the region of the TiO absorption bands between 4500 and 5000 Å, are given in the text.

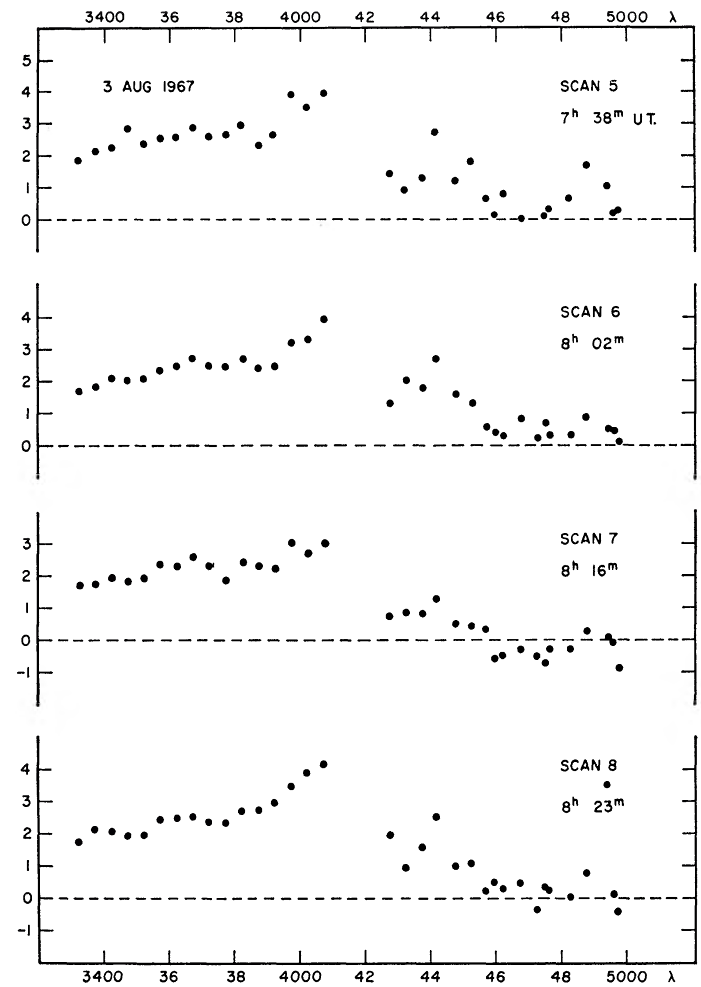

FIG 1.—*Continued*

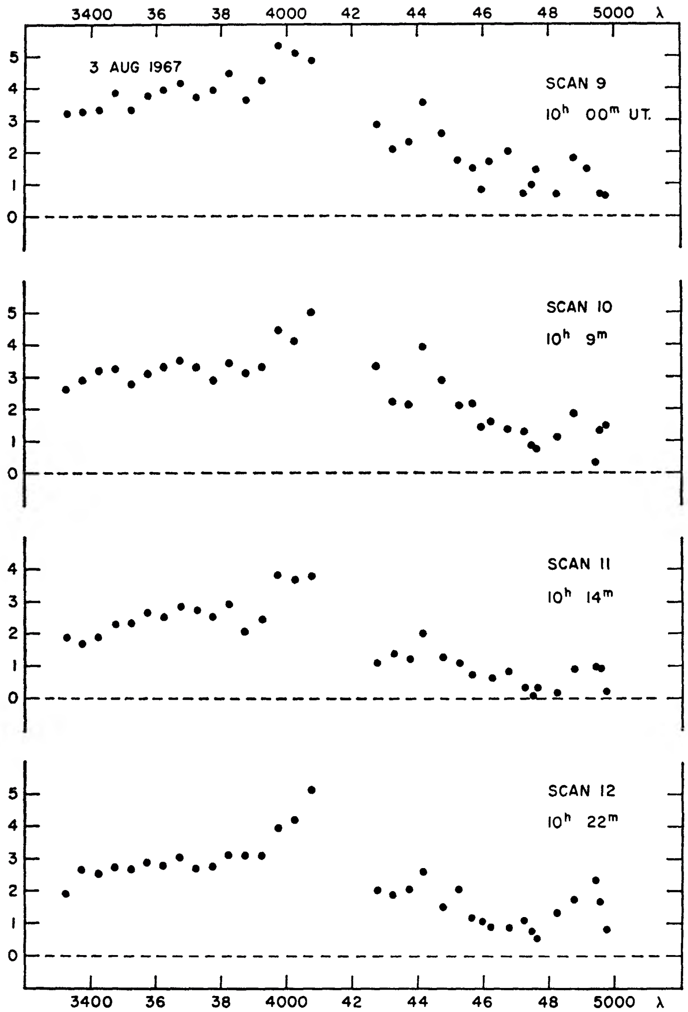

FIG. 1.—*Continued*

TABLE 2

INTEGRATED Hβ EMISSION IN UNITS OF ÅNGSTROMS AND RELATIVE FLUX (AS FIGURE 1)

Scan No	$W_{H\beta}$	Scan No	$W_{H\beta}$
1	2 58	7	1 73
2	1 94	8	1 67
3	1 45	9	2 31
4	1 60	10	2 01
5	1 52	11	2 15
6	1 79	12	1 94

In Figure 2 the emission measures of Hβ are plotted against the average ultraviolet continuum height near 3500 Å. It is clear from Figure 1 that the greater part of the emission comes from the Balmer continuum and line emission.

Figure 3 (Plate 4) shows a spectrogram (one-prism dispersion) of CH Cygni taken before the outburst in June by Yamashita, and a grating spectrogram of 45 Arietis. The Balmer emission lines show broad asymmetrical emission wings flanking an apparent absorption core. Among the higher members of the series these emission wings merge to an apparent continuum near the Balmer limit. The main features of the emission-line spectrum have already been described by Swings and Swings (1967) and Faraggiana (1968).

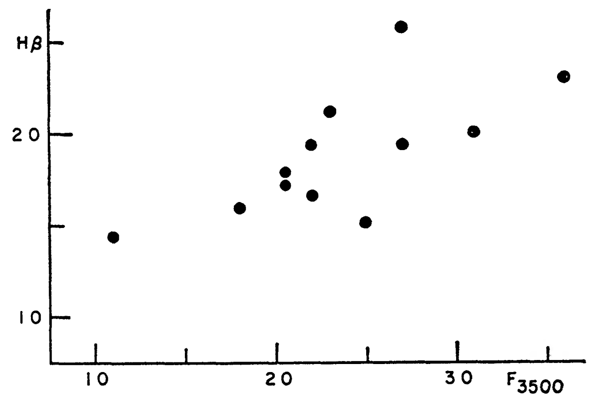

FIG. 2.—Emission measures of Hβ taken from Table 2 plotted against the ultraviolet excess continua near 3500 Å in Fig. 1.

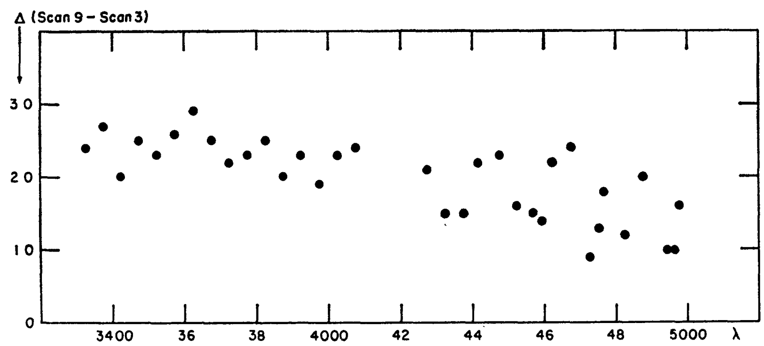

FIG. 4.—Difference between the excess continua for scans 3 and 9

In Figure 1 the decrease in intensity of the continuum at wavelengths shorter than 3650 Å and the absence of appreciable continuum at wavelengths longer than 4300 Å indicate that Balmer continuum emission is the only likely explanation for the major part of the continuum observed on the short-wavelength side of 3650 Å. The rough correlation between the continuum height and the Hβ emission measures in Figure 2 is confirmation of this.

CH Cygni is at a galactic latitude of 15° and Wallerstein (1968) suggests that the interstellar reddening may not be much greater than $E_{(B-V)} = 0.03$, which would not significantly affect the results in Figure 1. Hayes (1967) has recalibrated the absolute flux distribution in the spectrum of Vega and has shown that the absolute calibration of Oke's standards at wavelengths shorter than 3650 Å needs revision in the sense of increasing the Balmer discontinuity. The decrease in continuum intensity shown in Figure 1 would therefore be accentuated.

There is, according to our reduction procedure, a weak blue-green continuum evident for those scans in which the Balmer continuum is particularly bright. In Figure 4 the

PLATE 4

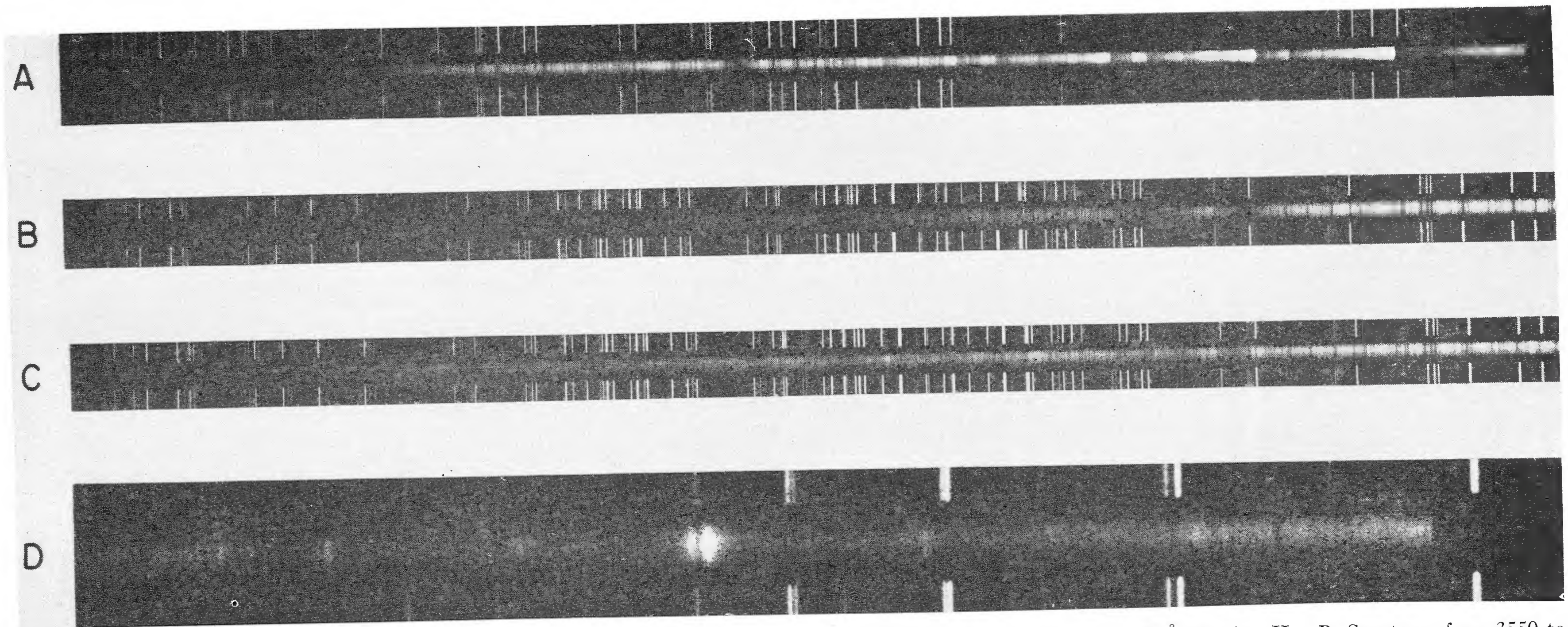

FIG. 3.—*A:* Preoutburst spectrum from 3800 to 5100 Å of CH Cygni taken on June 30, 1966, prismatic dispersion 30 Å mm^{-1} at $H\gamma$. *B:* Spectrum from 3550 to 4080 Å of 45 Arietis taken on August 22, 1967, grating dispersion 15 Å mm^{-1}. *C:* Spectrum from 3550 to 4080 Å of CH Cygni taken on August 3, 1967, grating dispersion 15 Å mm^{-1}. *D:* Enlargement of the region of $H\beta$ from the same plate as *C*.

WALKER *et al.* (*see* page 122)

differences between scans 3 and 9 are plotted against wavelength. The additional radiation at scan 9 appears to increase with a decreasing wavelength. This could possibly come from a hot, black-body source or synchrotron radiation, but the data are not sufficient to decide between these two or some third mechanism. The emission at Hβ also increases; it was measured as 1.45 on scan 3 and 2.31 on scan 9. This again suggests flare activity.

The results in Figure 1 are very similar to those found by Kunkel (1968) for dMe flare stars such as EV Lac, YZ CMi, and AD Leo. The flares for these stars are short lived (about 10 minutes) and recur at irregular intervals. This suggests that a similar larger flare or series of flares has occurred on CH Cygni.

Lovell, Whipple, and Solomon (1963) have detected coincident optical and radio (240-MHz) emission during flares of UV Cet, Ross 882, and EV Lac. It would be worthwhile looking for radio emission during outbursts of CH Cygni.

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